The emergence of "particle resonance": concepts formation and the materiality of theory

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My paper will discuss the emergence of the concept of “resonance” in particle physics (ca.1950-60), using this fascinating historical process to demonstrate a heuristic approach to the integrated historical and philosophical study of concept formation which focuses on the representational strategies associated to a scientific notion, regarding them as constituting its intrinsic material and performative dimensions. My aim is not to propose some new theory of concepts and meaning, but rather to extend to the study of physical-mathematical notions the insights achieved primarily in the investigation of experimental practices - results showing the importance of exploring knowledge construction in its material, performative and representational aspects.

Scientific concepts are accessible to historical and philosophical analysis only insofar as they are expressed and communicated in specific ways in situated contexts, and as such possess a material and performative component which can only be neglected at the risk of analysing not scientific practices, but their idealized, disembodied reconstructions. While in the last decades the intimate link between concept formation and the material, performative and representational aspects of knowledge production has been recognized for notions with a closer link to experiment, conceptual practices involving physical-mathematical formalisms are still usually approached as if they were disembodied, or as if their representations were epistemically contingent. Yet all modes of scientific representation are embodied and have special epistemic relevance because of their variety (symbols, words, images, formulas, measurement units, instruments, standard procedures) and interconnectedness: a concept emerging within a specific experimental set-up can come to be expressed in words or formulas, and eventually regarded as embedded in other instrumental practices. The border between experimental and theoretical concepts dissolves between modes of representation, and so a focus on the “materiality of theory” may help redress the balance between the study of conceptual developments in theoretical and experimental practices and further explore the epistemic role of concepts in the interplay of the two not-so-distinct domains.

Since the “practical turn” in science studies, attempts at reconstructing the formation of physical-mathematical notions like “electromagnetic field” or “electron” have been undertaken primarily as case studies to develop some general theory of concepts and meaning. While this goal is of course a thoroughly valuable philosophical focus, the integrated historical and philosophical study of the formation of physical-mathematical concepts cannot be limited to it. Scientific concepts, and in particular those which appear most abstract, are a fundamental actors’ category in past and present scientific practices, and thus it is important to investigate their development and epistemic significance without having to commit to some theory of meaning valid beyond the situated context of a study. At the same time, to avoid falling back into “whiggish” historiography, the investigation should be brought forward in a philosophically reflective way, regarding the formation of abstract concepts as a cultural process embedded in specific historical constellations, and not as the progressive sharpening of timeless, disembodied ideas about nature. Finding a balance between the two extremes is a challenge, but I will argue that the history of physical-mathematical concepts can be fruitfully approached by regarding the material and performative variety (and occasional incoherence) of their representations not as a hindrance to be removed or ignored, but as the best entry point for reconstructing and contextualizing their significance for historical actors, and for comparing epistemic constellations situated in different times or cultures.

I will illustrate my statements by discussing how the concept of “resonance” emerged in particle physics through the formation of a “pidgin” network involving verbal, mathematical, numerical and visual expressions. In the early 1950s newly-built particle accelerators made pion-nucleon scattering experiments possible: their results appeared in form of number tables and plots, and physicists were challenged with the task of finding some means (numbers, formulas, verbal statements, diagrams...) capable of matching them. Since the “high theories” of the time, notably quantum field theory, delivered no concrete connection to these data, some (mainly young) theorist turned to theoretical strategies from previous decades: the Breit-Wigner formula for nuclear resonances, the term “isobar” and its qualitative features from certain theories of nuclear forces, the spin-inspired structures of spectroscopic multiplets and some simple group-theoretical formulas. A tentative, but iconic match of theory and experiment was first achieved in form of the ratio 9:2:1 and, to test and expand it, new modes of mediation were employed, among them the first computer- aided data analyses in particle phyiscs, performed on Los Alamos’ MANIAC computer, and hybrid verbal-mathematical arguments based on a notion of causality. Eventually, the term “resonance” came to be seen as representing a new physical phenomenon about whose existence and features physicists however widely disagreed. Yet the various representations of “resonances" mediated between specialized knowledge areas, transforming a disciplinary borderline into a conceptually new research field. Eventually, the simple label of the first resonance, I(3/2, 3/2), became a key template for a new particle concept.